SP-E1.3 Oroville Reservoir Temperature Model Development

October 25, 2002

1.0 Introduction/Background

The Oroville Reservoir operations play a significant role in controlling the temperatures downstream on the Feather River. The release from Oroville Reservoir and their temperatures are critical in meeting the often-conflicting temperature requirements for downstream fishery purposes and agricultural diversions. There is a temperature control structure on the existing reservoir inlet that works to allow control of release temperatures and management of the cold-water pool in Oroville Reservoir. Evaluation of alternative reservoir operations impacts on release temperatures requires development of an Oroville Reservoir temperature model.

2.0 Study Objective

The goal of this study is to develop a temperature model for Oroville Reservoir that can simulate release temperature under different operational alternatives and benchmark simulations. Simulation of the spatial temperature distribution within Oroville Reservoir or of other water quality constituents such as DO and pH are not considered in the model development process. Initial co-ordination efforts have indicated that these issues are not of concern at this time.

If these issues become of concern later in the process the model developed under this study plan may not be appropriate for use and additional model development may be required.

3.0 Relationship to Relicensing /Need for the Study

In order for the Oroville facilities to obtain a new license the Federal Energy Regulatory Commission (FERC) requires water quality certification from the State Water Quality Control Board (SWRCB). The certification requires that SWRCB determine that the project complies with the temperature requirements of the Central Valley Water Resource Control Board (CVWRCB) Basin Plan (SPW1, 01). This study will enhance the information developed for FERC.

There is a need for the development of a temperature model for the Oroville Reservoir to allow simulation of release temperature for use in other study plans and as input to other modeling efforts.

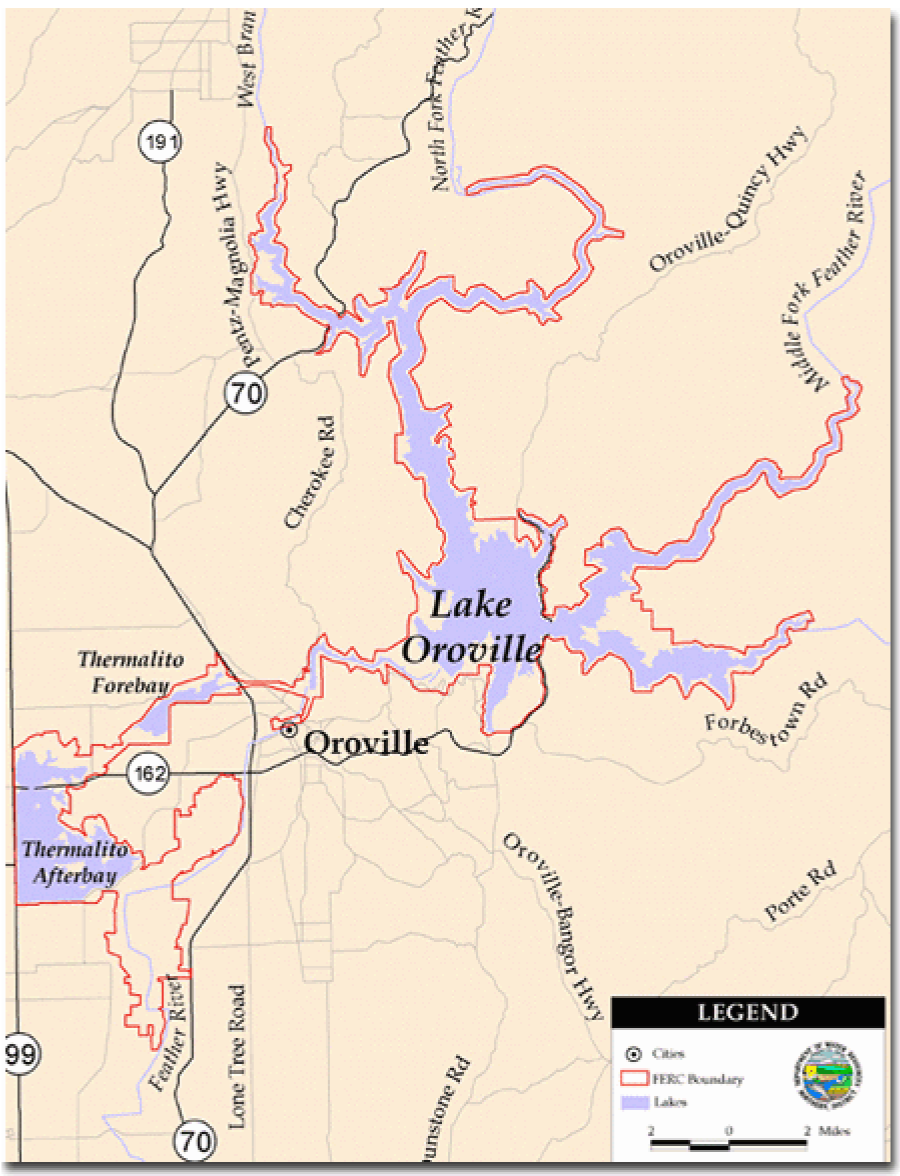
Engineering and Operations Issues Addressed

- E4—evaluate environmental and economic aspects of different flow regimes of Oroville Facilities operations. Factors to be considered include timing, magnitude and duration of flows, pump-back scheduling and maintenance scheduling, and hatchery operations.
- E6—effect of ramping rates on downstream facilities, power generation, water supply, water temperatures, and fish.

- E12—evaluate operational and engineering alternatives including selective withdrawal from Lake Oroville, Thermalito Afterbay, the hatchery, and the low flow section to meet various downstream temperature requirements.
- E14—evaluate operational alternatives that balance and maintain acceptable water quality standards including those for MTBE under all operational plans and conditions.

4.0 Study Area

The study area includes Oroville Reservoir including inflows and releases. Geographic scope may be refined as additional information is developed and needs are identified through collaboration with other Work Groups.



5.0 General Approach

This study will evaluate potential models and tools that could be used to develop a temperature model of Oroville Reservoir. The resulting model will be capable of simulating the release temperatures under various operational alternatives.

Task 1—Define Desired Outputs from the Model

As currently formulated the required products from this model include:

- Oroville release temperature
- Oroville reservoir temperature profile at intake structure

Additional desired outputs may be identified as the study plans from other work groups are completed and the process proceeds.

Task 2—Review Existing Models

This task will research existing models that could be used in the study plan. Currently identified models include:

- **USBR Temperature Model** (Rowell, 1990)
  The model simulates one-dimensional, vertical distribution of Oroville Reservoir water temperature using monthly input data on initial storage and temperature conditions, inflow, outflow, evaporation, precipitation, radiation and average air temperature. It also has been integrated with a river temperature model (FEATEMP) for downstream predictions on the lower Feather River. The USBR monthly temperature model (HEC) is used in conjunction with PROSIM, a reservoir operations model, to develop relationships between upstream reservoir impacts from Oroville Reservoir on downstream river temperature. This model has had limited verification and use.
- **HEC-5Q** (USACE-HEC 1987c), (Deas and Lowney, 2001)
  The Corps of Engineers developed a daily time step model of the Sacramento River Basin, including the Feather River using the HEC-5Q modeling tool. The model was used for instructional purposes by the Corp in preparation of their Training Document 24. The HEC-5Q modeling tool used simulates a one-dimensional, vertical temperature distribution for reservoirs; and a one-dimensional, longitudinal distribution for rivers. Reservoir-river simulations can be processed in a single run and includes comprehensive operations logic to accommodate operations (e.g. flood control, hydropower production).

Task 3—Review Existing Data

Types of data required include:

- Reservoir inflow, outflow
- Reservoir outlet configuration
- Stratification data
- Storage-area curve
- Storage-elevation curve
- Target temperature

- Inflow temperatures
- Air temperatures
- Evaporation
- Solar radiation
- Air temperature coefficient
- Inflow mixing coefficient
- Vertical diffusion coefficient
- Evaporation coefficient
- Insolation coefficient
- Heat exchange coefficient
    - Air temperature
    - Solar radiation
    - Relative humidity
    - Wind speed
    - Cloud cover
    - Solar altitude
    - Solar reflectivity

Existing data identified at this time is listed in Attachments A and B.

Task 4—Review Modeling Tools

There are a number of modeling tools that may be appropriate for use to build the Oroville Reservoir Temperature Model. The existing modeling tools include the following:

- **WQRRS** (USACE-HEC 1986), (Deas and Lowney, 2001)
    - Model was used on the North Fork of the Stanislaus River (Smith, 1981), and Shasta and Trinity reservoirs (Orlob et al. 1993) and Meyer and Orlob, 1994) to develop relationships between upstream reservoirs and downstream river temperature effects.
    - Developed by the ACE
    - Can also be used as a reservoir and river temperature model
    - Reservoir-river simulations must be processed separately
    - One-dimensional, vertical temperature distribution for reservoirs; one-dimensional, longitudinal distribution for rivers.
    - Hourly timestep
    - Includes broad range of water quality and ecological processes
- **RMA** (Deas and Lowney, 2001)
    - Versions 2 and 11 predict flow and temperature, respectively
    - This model generates hourly predictions
    - Both versions are one-dimensional
    - They model both reservoirs and streams
    - They have been applied to the Sacramento and Feather rivers, and Keswick reservoir (Deas et al., 1997, Jensen et al., 1999)
- **BETTER** (TVA, 1990), (Deas and Lowney, 2001)
    - This model generates daily predictions

    - It predicts temperatures in reservoirs both vertically and longitudinally
    - It models water quality in reservoirs only
    - It has been applied to the Lewiston and Whiskey Town reservoirs and releases to the Trinity River
- **CE-QUAL-W2** (Deas and Lowney, 2001)
    - Models reservoir water quality in two dimensions, vertically and longitudinally
    - Has been applied by Hanna, et al. (1999) to evaluate the effects of operations on temperature control device on reservoir thermal regime
- **MIKE-11**
    - Simulates rivers and reservoirs
    - Dynamic, one dimensional
    - Consists of many modules for specific modeling simulations which can be run in conjunction or separately.

Each of these tools, and possibly others, will be evaluated for suitability to meet the needs identified in Task 1.

Task 5—Select Appropriate Model or Modeling Tool

Based on the results of task 1 through 4 select the appropriate model/modeling tool to create the Oroville Reservoir Temperature Model. The workgroup will approve the model/modeling tool selection.

Task 6—Collect Field Data for Development/Calibration/Verification

Each model or modeling tool requires specific data for development/calibration/verification purposes. Once the model or modeling tool has been selected the specific data required to perform these tasks can be identified and compared to all known existing data to see if additional data is required to complete the model development.

Subtasks for this include:

- Identify additional data required;
- Install instrumentation as required; and,
- Collect data.

Task 7—Complete Model Development/Calibration/Verification

This task is the actual development of the Oroville Reservoir Temperature Model. Typical model development subtasks include:

- Select model/modeling tool for use
- Develop physical system definition in model
- Develop time-series input data (hydrologic, operational)
- Identify additional required data including type of data, quality of data and locations for collection. Specify monitoring needs including instrumentation and data collection processes required to obtain the data.
- Begin model development with existing data. Use assumed values for additional required data until it is collected.

The Oroville Reservoir Temperature Model has two additional factors which may need to be considered in it development. The Oroville-Thermalito complex can operate in a pumpback mode to use cheaper, off peak energy to pump water back into Oroville Reservoir for reuse to generate energy during the more valuable, on peak hours of the day. The water that is pumped back into Oroville Reservoir may have been subject to heating in the Thermalito Forebay-Afterbay complex and may be warmer when pumped back then it was when it was released. The extent of the temperature impact on Oroville Reservoir will need to be investigated to see if it should be considered in the modeling. Implementation of this feature into the Oroville Reservoir Temperature model may require modifications to the selected modeling tool. A separate study plan has been developed to investigate this issue.

There are two main ways to operate a reservoir for temperature control of its releases, "real time" and "seasonal". "Real time" operation, where the temperatures are managed only for the present and near future needs is different than "seasonal" operation, where availability of cold water for temperature control in other times of the year is important. The "seasonal" type of operation usually occurs when the available cold-water pool in the reservoir is not expected to be large enough to meet the "real time" objectives each day for the rest of the year. In that case temperature operations today must take into account their impacts on temperature operations in the future. The availability of the cold water pool in Oroville reservoir will need to be investigated to see evaluate need for "seasonal" temperature operations criteria. A separate study plan has been developed to investigate this issue. Implementation of a "seasonal" type operation could require modifications to the modeling tool or development of addition tools to implement the seasonal temperature operational goals.

Inclusion of these two potential issues results in the following subtasks for this model:

- Select model/modeling tool for use
- Develop physical system definition in model
- Develop time-series input data (hydrologic, operational)
- Identify additional required data including type of data, quality of data and locations for collection. Specify monitoring needs including instrumentation and data collection processes required to obtain the data.
- Begin model development with existing data. Use assumed values for additional required data until it is collected.
- Perform model modifications, if required, for pumpback operations
- Calibrate/verify the model
- Develop "seasonal" operation tools or model modifications if required

The calibration/verification process will likely be the longest process involved in the study plan.

Task 8—Integrate Completed Model into Model Development Scheme

Integration of the model into the model development scheme will require development of the transfer utilities defined in Study E 1. These transfer utilities will be used for three main purposes:

- Extract data from the central modeling database, modify this data as required for input to the Oroville Reservoir Temperature

- Extract data from the Oroville Reservoir Temperature Model output files, perform any computation on them that may be required and store the results in the central modeling database
- Allow review of all data being transferred for quality control purposes

Task 9—Perform Benchmark Simulations

Using the developed model perform the Oroville Release Temperature simulations required for the initial Benchmark Studies.

- Get boundary conditions from central modeling database
- Use utility programs to create input based on the boundary conditions
- Perform the actual simulations
- Use utility programs to load data into central modeling database

6.0 Results and Products/Deliverables

Results

This study plan will result in a temperature model capable of simulating temperatures for various operating scenarios in the Oroville Reservoir. It will output release temperatures from the dam that will be utilized for impact analysis and/or as input to other modeling efforts.

Products/Deliverables

There will be two products from this study plan:

- An Oroville Reservoir temperature model that can simulate release temperatures. The model will include pumpback impacts if required and will be capable of modeling both real time and seasonal temperature operation constraints for cold-water pool management. This product will be fully integrated into the overall modeling scheme.
- Simulated Oroville Reservoir temperature profiles and release temperature data for the benchmark studies for use in other analysis.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

This study will be coordinated with a number of other Engineering and Operation study plans:

- Study Plan #1—Model Development
- Study Plan #1b—Local Operations Model Development
- Study Plan #1d—Thermalito Complex Temperature Model Development
- Study Plan #1e—Feather River Temperature Model Development
- Study Plan #2—Modeling Simulation
- Study Plan #6—Oroville Reservoir Cold Water Pool Analysis

- Study Plan #7—Temperature Impacts of Pumpback Operations at Oroville Reservoir

The development will also be coordinated with study plans from other workgroups that will require Oroville Reservoir temperature profiles and release temperatures.

Issues, Concerns, Comments Tracking and/or Regulatory Compliance Requirements

In order for the Oroville facilities to obtain a new license the Federal Energy Regulatory Commission (FERC) requires water quality certification from the State Water Quality Control Board (SWRCB). The certification requires that SWRCB determine that the project complies with the temperature requirements of the Central Valley Water Resource Control Board (CVWRCB) Basin Plan (SPW1, 01). This study will enhance the information developed for FERC.

8.0 Study Schedule

This section to be developed.

9.0 References

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United States Army Corp of Engineers – Hydrologic Engineering Center (USACE-HEC) 1987c. *Simulation of flood control and conservation systems: appendix on water quality analysis.* September.

Attachment A
State Water Project Operation Data

	Location	Data Description	Data Description 2	Units	Data Type	Start Date	End Date	Data Source
1	Lake Oroville	Water Surface Elevation		Feet	Daily	Jan-90	Present	SWP
2	Lake Oroville	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
3	Lake Oroville	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
4	Lake Oroville	Outflow	Hyatt Powerplant	Acre-Feet	Daily	Jan-90	Present	SWP
5	Lake Oroville	Outflow	Palermo Canal	Acre-Feet	Daily	Jan-90	Present	SWP
6	Lake Oroville	Outflow	Evaporation	Acre-Feet	Daily	Jan-90	Present	SWP
7	Lake Oroville	Outflow	Spill	Acre-Feet	Daily	Jan-90	Present	SWP
8	Lake Oroville	Outflow	Total Outflow	Acre-Feet	Daily	Jan-90	Present	SWP
9	Lake Oroville	Inflow	Hyatt Powerplant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
10	Lake Oroville	Inflow	Computed Inflow	Acre-Feet	Daily	Jan-90	Present	SWP
11	Thermalito Forebay	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
12	Thermalito Forebay	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
13	Thermalito Forebay	Inflow	Lake Oroville Releases	Acre-Feet	Daily	Jan-90	Present	SWP
14	Thermalito Forebay	Inflow	Kelly Ridge Generation	Acre-Feet	Daily	Jan-90	Present	SWP
15	Thermalito Forebay	Inflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
16	Thermalito Forebay	Outflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
17	Thermalito Forebay	Outflow	Butte County	Acre-Feet	Daily	Jan-90	Present	SWP
18	Thermalito Forebay	Outflow	Thermalito Irrigation District	Acre-Feet	Daily	Jan-90	Present	SWP
19	Thermalito Forebay	Outflow	Releases to River	Acre-Feet	Daily	Jan-90	Present	SWP
20	Thermalito Forebay	Outflow	Hyatt Powerplant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
21	Thermalito Forebay	Losses and Gains		Acre-Feet	Daily	Jan-90	Present	SWP
22	Thermalito Afterbay	Water Surface Elevation		Feet	Daily	Jan-90	Present	SWP
23	Thermalito Afterbay	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
24	Thermalito Afterbay	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
25	Thermalito Afterbay	Inflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
26	Thermalito Afterbay	Outflow	Sutter Butte Canal	Acre-Feet	Daily	Jan-90	Present	SWP
27	Thermalito Afterbay	Outflow	Western Canal Lateral	Acre-Feet	Daily	Jan-90	Present	SWP
28	Thermalito Afterbay	Outflow	Richvale Canal	Acre-Feet	Daily	Jan-90	Present	SWP
29	Thermalito Afterbay	Outflow	Western Canal	Acre-Feet	Daily	Jan-90	Present	SWP

	Location	Data Description	Data Description 2	Units	Data Type	Start Date	End Date	Data Source
30	Thermalito Afterbay	Outflow	Afterbay River Outlet	Acre-Feet	Daily	Jan-90	Present	SWP
31	Thermalito Afterbay	Outflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
32	Thermalito Afterbay	Losses and Gains		Acre-Feet	Daily	Jan-90	Present	SWP
33	Thermalito Afterbay	Total Releases to River		Acre-Feet	Daily	Jan-90	Present	SWP
34	Oroville-Thermalito Complex	Mean Daily Water Temperature	Thermalito Afterbay Outlet	Fahrenheit	Daily	Jan-90	Present	SWP
35	Oroville-Thermalito Complex	Mean Daily Water Temperature	Fish Hatchery	Fahrenheit	Daily	Jan-90	Present	SWP
36	Oroville-Thermalito Complex	Lake Oroville Temperature Profile	Graph of Temp by Elevation	Fahrenheit/Feet	Daily	Jan-90	Present	SWP
37	Oroville and Delta Field Divisions Energy Data	Oroville-Thermalito Complex	Generation	KWH	Daily	Jan-90	Present	SWP
38	Oroville and Delta Field Divisions Energy Data	Oroville-Thermalito Complex	Load	KWH	Daily	Jan-90	Present	SWP
39	Oroville and Delta Field Divisions Energy Data	Baker Slough Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
40	Oroville and Delta Field Divisions Energy Data	Cordelia Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
41	Oroville and Delta Field Divisions Energy Data	Banks Pumping Plant	Total Load	KWH	Daily	Jan-90	Present	SWP
42	Oroville and Delta Field Divisions Energy Data		SWP Load	KWH	Daily	Jan-90	Present	SWP
43	Oroville and Delta Field Divisions Energy Data	South Bay Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
44	Oroville and Delta Field Divisions Energy Data	Del Valle Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP

Attachment B
California Data Exchange Center

Ensor	Data Description	Data Type	Start Date	End Date	Station	Hydrologic Area
1	RIVER STAGE (feet)	(event)	9/10/1997	present	FEATHER RIVER AT BOYD'S LANDING (FBL)	
1	RIVER STAGE (feet)	(event)	9/10/1997	present	FEATHER RIVER AT LIVE OAK (FLO)	
1	RIVER STAGE (feet)	(event)	2/23/1995	present	FEATHER RIVER AT YUBA CITY (YUB)	
1	RIVER STAGE (feet)	(event)	1/5/1999	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
1	RIVER STAGE (feet)	(event)	2/23/1995	present	FEATHER RIVER NEAR NICOLAUS (NIC)	
1	RIVER STAGE (feet)	(event)	2/10/1998	present	NORTH FORK FEATHER RIVER AT PULGA (PLG)	
1	RIVER STAGE (feet)	(hourly)	10/7/1997	present	FEATHER RIVER AT LIVE OAK (FLO)	
1	RIVER STAGE (feet)	(hourly)	1/5/1984	present	FEATHER RIVER AT MERRIMAC (MER)	
1	RIVER STAGE (feet)	(hourly)	1/1/1984	present	FEATHER RIVER AT YUBA CITY (YUB)	
1	RIVER STAGE (feet)	(hourly)	1/1/1984	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
1	RIVER STAGE (feet)	(hourly)	1/1/1984	present	FEATHER RIVER NEAR NICOLAUS (NIC)	
1	RIVER STAGE (feet)	(hourly)	3/18/1998	present	NORTH FORK FEATHER RIVER AT PULGA (PLG)	
2	PRECIPITATION, ACCUMULATED (inches)	(hourly)	1/1/1984	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
2	PRECIPITATION, ACCUMULATED (inches)	(monthly)	10/1/1962	present	FEATHER RIVER NEAR NICOLAUS (NIC)	
2	PRECIPITATION, ACCUMULATED (inches)	(monthly)	10/1/1989	5/1/1994	OROVILLE FISH HATCH. (ORF)	
2	PRECIPITATION, ACCUMULATED (inches)	(monthly)	10/1/1939	9/1/1991	OROVILLE RS (ORS)	
3	SNOW, WATER CONTENT (inches)	(monthly)	4/1/1930	present	FEATHER RIVER MEADOW (FEM)	
6	RESERVOIR ELEVATION (feet)	(daily)	2/14/1985	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
6	RESERVOIR ELEVATION (feet)	(hourly)	1/1/1984	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
7	RESERVOIR, SCHEDULED RELEASE (cfs)	(event)	10/1/1995	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
8	FULL NATURAL FLOW (cfs)	(daily)	4/21/1985	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
14	BATTERY VOLTAGE (volts)	(event)	7/31/2000	present	FEATHER RIVER AT MILE 61.6 (FRA)	
14	BATTERY VOLTAGE (volts)	(event)	2/23/1995	present	FEATHER RIVER AT YUBA CITY (YUB)	
14	BATTERY VOLTAGE (volts)	(event)	1/5/1999	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
14	BATTERY VOLTAGE (volts)	(event)	2/23/1995	present	FEATHER RIVER NEAR NICOLAUS (NIC)	
14	BATTERY VOLTAGE (volts)	(hourly)	10/7/1997	present	FEATHER RIVER AT LIVE OAK (FLO)	
14	BATTERY VOLTAGE (volts)	(hourly)	1/1/1995	present	FEATHER RIVER AT MERRIMAC (MER)	
14	BATTERY VOLTAGE (volts)	(hourly)	1/1/1995	present	FEATHER RIVER AT YUBA CITY (YUB)	
14	BATTERY VOLTAGE (volts)	(hourly)	1/1/1995	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
14	BATTERY VOLTAGE (volts)	(hourly)	1/1/1995	present	FEATHER RIVER NEAR NICOLAUS (NIC)	
14	BATTERY VOLTAGE (volts)	(hourly)	2/19/1998	present	NORTH FORK FEATHER RIVER AT PULGA (PLG)	
14	BATTERY VOLTAGE (volts)	(hourly)	1/1/1995	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER

Ensor	Data Description	Data Type	Start Date	End Date	Station	Hydrologic Area
15	RESERVOIR STORAGE (af)	(daily)	2/13/1985	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
15	RESERVOIR STORAGE (af)	(daily)	1/1/1985	present	THERMALITO AFTERBAY (TAB)	
15	RESERVOIR STORAGE (af)	(hourly)	1/1/1984	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
15	RESERVOIR STORAGE (af)	(monthly)	10/1/1967	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
15	RESERVOIR STORAGE (af)	(monthly)	10/1/1967	present	THERMALITO AFTERBAY (TAB)	
15	RESERVOIR STORAGE (af)	(monthly)	10/1/1969	present	THERMALITO DIVERS POOL (THD)	
15	RESERVOIR STORAGE (af)	(monthly)	10/1/1969	present	THERMALITO FOREBAY (TFR)	
15	RESERVOIR STORAGE (af)	(monthly)	10/1/1969	present	THERMALITO TOTAL (TMT)	
20	FLOW, RIVER DISCHARGE (cfs)	(event)	1/5/1999	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
20	FLOW, RIVER DISCHARGE (cfs)	(event)	2/10/1998	present	NORTH FORK FEATHER RIVER AT PULGA (PLG)	
20	FLOW, RIVER DISCHARGE (cfs)	(hourly)	1/5/1984	present	FEATHER RIVER AT MERRIMAC (MER)	
20	FLOW, RIVER DISCHARGE (cfs)	(hourly)	1/1/1984	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
20	FLOW, RIVER DISCHARGE (cfs)	(hourly)	3/18/1998	present	NORTH FORK FEATHER RIVER AT PULGA (PLG)	
22	RESERVOIR, STORAGE CHANGE (af)	(daily)	10/1/1993	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
23	RESERVOIR OUTFLOW (cfs)	(daily)	1/5/1987	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
23	RESERVOIR OUTFLOW (cfs)	(hourly)	2/6/1998	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
25	TEMPERATURE, WATER (deg f)	(event)	7/31/2000	present	FEATHER RIVER AT MILE 61.6 (FRA)	
41	FLOW, MEAN DAILY (cfs)	(daily)	1/1/1993	present	FEATHER RIVER AT MERRIMAC (MER)	
41	FLOW, MEAN DAILY (cfs)	(daily)	1/1/1993	present	FEATHER RIVER NEAR GRIDLEY (GRL)	
45	PRECIPITATION, INCREMENTAL (inches)	(daily)	1/1/1987	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
65	FLOW, FULL NATURAL (af)	(monthly)	10/1/1925	8/1/1992	FEATHER MF NR CLIO (FTC)	
65	FLOW, FULL NATURAL (af)	(monthly)	10/1/1907	9/1/1970	FEATHER MF NR MERRIMAC (FTM)	
65	FLOW, FULL NATURAL (af)	(monthly)	10/1/1911	9/1/1995	FEATHER NF AT PULGA (FPL)	
65	FLOW, FULL NATURAL (af)	(monthly)	2/1/1905	9/1/1992	FEATHER NF NEAR PRATTVILLE (FPR)	
65	FLOW, FULL NATURAL (af)	(monthly)	10/1/1905	present	FEATHER R (OROVILLE) (FTO)	SACRAMENTO RIVER
65	FLOW, FULL NATURAL (af)	(monthly)	10/1/1900	9/1/1992	FEATHER SF AT PONDEROSA (FTP)	
66	FLOW, MONTHLY VOLUME (af)	(monthly)	10/1/1925	10/1/1925	FEATHER MF NR CLIO (FTC)	
66	FLOW, MONTHLY VOLUME (af)	(monthly)	10/1/1907	10/1/1907	FEATHER MF NR MERRIMAC (FTM)	
66	FLOW, MONTHLY VOLUME (af)	(monthly)	10/1/1911	10/1/1911	FEATHER NF AT PULGA (FPL)	
66	FLOW, MONTHLY VOLUME (af)	(monthly)	1/1/1905	present	FEATHER R (OROVILLE) (FTO)	SACRAMENTO RIVER
66	FLOW, MONTHLY VOLUME (af)	(monthly)	10/1/1900	10/1/1900	FEATHER SF AT PONDEROSA (FTP)	
68	EVAPORATION, LAKE COMPUTED (af)	(monthly)	10/1/1985	present	OROVILL-THERMALITO (ORT)	
69	FLOW, CANAL DIVERSION (AF) (af)	(monthly)	10/1/1985	present	FEATHER R (OROVILLE) (FTO)	SACRAMENTO RIVER
69	FLOW, CANAL DIVERSION (AF) (af)	(monthly)	3/1/1995	present	FEATHER RIVER(TRUCKE (FTT)	
69	FLOW, CANAL DIVERSION (AF) (af)	(monthly)	10/1/1985	present	THERMALITO FOREBAY (TFR)	
72	FLOW, IRRIG&CONSUMPTION (AF) (af)	(monthly)	10/1/1911	10/1/1911	FEATHER NF AT PULGA (FPL)	
74	EVAPORATION, LAKE COMPUTED (cfs)	(daily)	10/1/1994	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER

Ensor	Data Description	Data Type	Start Date	End Date	Station	Hydrologic Area
76	RESERVOIR INFLOW (cfs)	(daily)	1/1/1994	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
76	RESERVOIR INFLOW (cfs)	(hourly)	1/23/1997	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
85	DISCHARGE,CONTROL REGULATING (cfs)	(daily)	9/21/1999	present	TOTAL RELEASE-FEATHER R BLW THERMALITO (THA)	
85	DISCHARGE,CONTROL REGULATING (cfs)	(hourly)	2/5/1998	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
85	DISCHARGE,CONTROL REGULATING (cfs)	(hourly)	2/5/1998	present	TOTAL RELEASE-FEATHER R BLW THERMALITO (THA)	
94	RESERVOIR, TOP CONSERV STORAGE (af)	(daily)	10/20/2000	present	OROVILLE DAM (ORO)	SACRAMENTO RIVER
110	FLOW, CANAL DIVERSION (CFS) (cfs)	(daily)	3/1/2001	present	FEATHER R (OROVILLE) (FTO)	SACRAMENTO RIVER